Mercury Emissions from Coal-fired Power Plants
Public Health and Welfare Finding Pursuant to Section 285.27(2)(b), Wisconsin Statutes

ADDENDUM

June 17, 2008

Wisconsin Department of Natural Resources
Bureau of Air Management

Overview

In the absence of a federal standard promulgated under section 112 of the Clean Air Act, the Department may promulgate a standard if it finds that a standard is needed to provide adequate protection of public health and welfare. This is a statutory requirement, s. 285.27(2)(b), Wis. Stats., that necessitates written documentation to support a finding that addresses the following:

- Identify sources of mercury emissions and populations potentially at risk;
- Assess whether exposures to mercury are above a level of concern;
- Evaluate options to control risks from mercury emissions exposures;
- Compare mercury emission standards proposed with those from neighboring states.

A preliminary finding was prepared and offered for public review and comment along with proposed revisions to Chapter NR 446, Control of Mercury Emissions, Wis. Adm. Code. The March 2008 preliminary finding concluded that a state mercury standard for coal-fired power plants was appropriate based on scientific research and technical analyses of mercury emissions sources, exposures, health effects, control options and comparisons to standards in neighboring states. A public hearing was held in Madison on April 7, 2008 and written comments on the preliminary finding and the proposed rule were accepted until May 5, 2008.

This addendum provides additional analyses that responds to significant concerns on the preliminary finding raised in public comments.

Section 1 - What are the Stationary Sources of Mercury Emissions and Populations at Risk?

Preliminary Finding Summary
Wisconsin air emission inventory data indicates that three major types of stationary sources are responsible for mercury air emissions in the state:

1. Coal-fired electric generating units.
2. ERCO Worldwide chlor-alkali facility in Port Edwards.
3. Industrial coal-fired power boilers.

Coal-fired electric generating units in Wisconsin currently account for 62.5% of stationary source mercury emissions. After a planned conversion in 2010 to a mercury-free process at ERCO Worldwide, coal-fired electric generating units will account for 86% of total mercury air emissions from stationary sources. Establishing a mercury emission standard for coal-fired electric generating units to protect public health and welfare is the most effective option since these plants are the stationary sources that account for the majority of mercury air emissions in Wisconsin. Emission control technologies are commercially available to reduce mercury releases from the types of coal-fired electric generating units operating in Wisconsin. Additional technologies, suitable for commercial application, will be available within the next seven years.

The Wisconsin Department of Health and Family Services (DHFS), federal governmental organizations and institutions have identified women of child-bearing age, infants and children as the populations at greatest risk from elevated mercury exposure. A study of Wisconsin women estimated that about 6% of women who are childbearing age had elevated mercury levels. A survey conducted by the Wisconsin DHFS in 1999 found that more than 90% of Wisconsin women between the ages of 18 and 45 include fish in their diets and approximately one-third of them consume sport-caught fish.

Comment
Forest County Potawatomi Community expressed their concern that the preliminary finding did not recognize the additional risk that tribal members face. In their comments they state "Although DNR's findings already support the need for quick and dramatic mercury reductions, we strongly recommend that the DNR amend its findings to include the fact that people who eat above-average amounts of fish, such as Native Americans and members of other specific cultures, are at a particular risk from mercury emissions".

Response Summary
NATIVE AMERICAN POPULATIONS THAT CONSUME LARGE AMOUNTS OF FISH ARE AT GREATER RISK THAN THE POPULATION AS A WHOLE

Response Analysis
Native Americans in Wisconsin are a population that is at risk. In their written comments, the Forest County Potawatomi Community provide documentation supporting their interest in having the public health and welfare finding recognize Native Americans as a population in Wisconsin that is subject to an increased health risk. According to the U.S. Environmental Protection Agency (EPA 822-B-00-004, October 2000, Methodology for Deriving Water Quality Criteria for the Protection of Public Health), Native Americans have greater exposure because their fish consumption has been determined to be greater than the general population. As stated in EPA 822-B-00-004:

The default fish consumption value for the general adult population in the 2000 Human Health Methodology is 17.5 grams/day, which represents an estimate of the 90th percentile consumption rate for the U.S. adult population based on the U.S. Department of Agriculture's (USDA's) Continuing Survey of Food Intake by Individuals (CSFII) 1994-96 data (USDA, 1998). EPA will use this default intake rate with future national 304(a) criteria derivations or revisions. This default value is chosen to be protective of the majority of the general population.

However, States and authorized Tribes are urged to use a fish intake level derived from local data on fish consumption in place of this default value when deriving AWQC, ensuring that the fish intake level chosen is protective of highly exposed individuals in the population. EPA has provided default values for States and authorized Tribes that do not have adequate information on local or regional consumption patterns, based on numerous studies that EPA has reviewed on sport anglers and subsistence fishers. EPA's defaults for these population groups are estimates of their average consumption. EPA recommends a default of 17.5 grams/day for sport anglers as an approximation of their average consumption and 142.4 grams/day for subsistence fishers, which falls within the range of averages for this group.

The Forest County Potawatomi Community believe they are at even greater risk than EPA default data suggests because their members fish and are heavy fish consumers from lakes on or near their lands that have documented mercury contamination. In addition, they point out that several nearby lakes have been identified by the Department as having special mercury concerns including Deep Hole Lake and Little Sand Lake (WDNR Special Advice for Mercury 2007).

Comment

We Energies questioned whether valid estimates of the populations at risk in Wisconsin can be made from the available data.

Response Summary

6% OF WOMEN AND 16% OF MEN RESIDING IN WISCONSIN CONSUME ENOUGH FISH TO RESULT IN HAIR MERCURY LEVELS GREATER THAN 1 PPM

Response Analysis

To estimate the number of Wisconsin residents potentially affected, the Department of Health and Family Services' study combined fish consumption data from the 2004 Behavioral Risk Factor Survey, which is a statistically valid sample of Wisconsin's adult population, with hair mercury levels and fish intake data from a group of 2,038 volunteers to develop an estimate of mercury exposure among the general population. This process was used to avoid biases that can result from self-selection of hair donors who may be concerned about their mercury exposure. The estimate that 6% of women and 16% of men consume enough fish to have a hair mercury level greater than 1 ppm was derived by integrating data from the 2004 Behavioral Risk Factor Survey with data from the hair testing study.

Section 2 - Are Exposures Above a Level of Concern?

Preliminary Finding Summary

A 2004 - 2005 survey of mercury concentrations in hair in Wisconsin study volunteers showed that 29% of men and 13% of women had mercury levels above 1 part per million (ppm), which is the level of concern for adverse effects determined by United States Environmental Protection Agency (EPA). It is estimated that approximately 437,000 men and women in Wisconsin are exposed to mercury above the safe level established by the EPA. The health risks include developmental effects such as lower performance on language, attention and memory tests and adverse effects in vision and motor functions. Recent research has also identified mercury effects on the immune system and a potential role of mercury exposure in elevating the risks of heart attacks in adults. Health effects experts worldwide have identified the reduction of mercury exposures as a major public health goal.

Comment

We Energies expressed concern about the appropriate health benchmark and suggested that there is not sufficient scientific evidence to conclude that in addition to women, infants and children, the general public is also at risk of adverse effects from methylmercury levels currently found in some fish.

Response Summary

EPA'S REFERENCE DOSE IS AN APPROPRIATE HEALTH BENCHMARK AND THAT BENCHMARK MAY PROVIDE ONLY A NARROW MARGIN OF SAFETY

Response Analysis

The following is a response from the state Department of Health of Health and Family Services (DHFS) related to this concern:

The Department of Health and Family Services believes there is sufficient evidence of a link between methylmercury and cardiovascular disease to take action to reduce mercury exposures in people of all ages and genders. Currently, the US EPA reference dose is the best benchmark we have to evaluate the health burden mercury contamination poses to the general public as well as to sensitive groups. The health department encourages people of all ages to eat fish that are low in mercury as part of a varied, healthy diet.

Comment

We Energies also questioned the health endpoint used by EPA and DHFS as well as the extrapolation method used to estimate affected Wisconsin populations.

Response Analysis

DHFS provided the following in response:

The Department of Health and Family Service recommends use of the EPA reference dose as the best available health guideline for mercury. In developing the reference dose, a single uncertainty factor of 10 was used to account for the lack of scientific study of the effects methylmercury may have on aging populations and on the immune and cardiovascular systems. Studies published by Salonen et al. 1995 and Grandjean et al. 2004 suggest that cardiovascular effects may occur at hair mercury levels as low as 2 to 4 ppm and that the current reference dose may provide a very narrow margin of safety.

Comment
We Energies commented that SO_4 deposition to Little Rock Lake in Vilas County declined by 45% during the 1994 to 2000 time period, possibly explaining the 30% decline in fish mercury.

We Energies commented that sulfate may play a more important role in mercury methylation and uptake in the fish population than mercury deposition.

Response Summary
REDUCTIONS IN MERCURY DEPOSITION WILL HAVE A GREATER EFFECT ON FISH CONTAMINATION THAN REDUCTIONS IN SULFATE

Response Analysis
Dr. Carl Watras, one of the authors of the article cited by We Energies, believes that this is a misinterpretation of the data and is uncertain where they derive the 45% estimate. His analysis of the mercury data from the National Atmospheric Deposition Program (NADP) for Wisconsin indicates that there is no statistically significant trend in SO_4 deposition over this time.

Dr. Watras provided the following concerning the role of atmospheric mercury deposition:

Research on lakes in Wisconsin and Canada demonstrates that reductions in mercury deposition will have a greater effect on fish contamination than reductions in sulfate. Studies on Little Rock Lake, Vilas County, show that changes in atmospheric mercury deposition have rapid effects on mercury concentrations in water and fish (Watras et al., 2000; Hrabik and Watras 2002). These studies indicate that new inputs of mercury are the major determinant of mercury contamination levels. The rapid incorporation of new mercury into aquatic food chains was confirmed recently by experimental additions of mercury isotopes to lakes in Canada (Paterson et al., 2006; Orihel et al, 2006; Harris et al., 2007). In contrast, reductions in sulfate deposition have a delayed effect rather than an immediate effect on mercury contamination. The delay results from the much longer half-life of sulfate compared to mercury in lake water (Urban and Monte, 2001; Watras et al., 2002). Thus, even though both mercury and sulfate co-mediate the production and bioaccumulation of methylmercury in sensitive Wisconsin lakes (e.g. Watras et al. 2006), the atmospheric deposition of mercury has the most immediate effect on contamination levels and public health.

Comment
We Energies commented that Common Loon reproduction may be harmed by factors other than mercury contamination of fish with other confounding factors playing a significant role in adverse effects on loon populations in Wisconsin.

Response Summary
MERCURY EXPOSURE IS A CRITICALLY IMPORTANT FACTOR THAT LIMITS LOON POPULATIONS

Response Analysis
Dr. Mike Meyer, Department researcher, has studied the effects of multiple stressors on loon populations and has evidence that mercury effects can be separated from these other stressors. He provided the following in response to the We Energies comment:

Common Loons have been found to have elevated Hg exposure when nesting on acidic lakes in Wisconsin, which is correlated with reduced productivity (Meyer et al. 1995, 1998). Mercury bioaccumulation impacts on loon populations are difficult to assess, due to confounding factors and the difficulty in measuring population dynamics in the field. Scientists in other regions have found habitat loss, water level fluctuations, predation and human disturbance to be associated with impacts on loon reproduction and survival. However, research in Wisconsin, New England, and the Canadian Maritimes has concluded that mercury exposure is a critically important factor that limits loon populations as well.

Recent findings measuring the relationship between brain neurochemistry and mercury exposure show that Common Loons are very sensitive to the toxicological effects of methylmercury, with ecologically relevant MeHg exposure levels associated with altered neurotransmitter concentrations (Scheuhammer et al. 2008). Scientists from USGS and WDNR (Kenow et al. 2003) dosed Common Loon chicks in captivity with fish containing MeHg (delivered in gelatin capsules) with concentrations bracketing and exceeding known loon prey Hg levels in North America. The experiment was conducted for 105 days post-hatch. No overt toxicity or reduction in growth rates were observed at any dose (Kenow et al., 2003) but evidence of reduced immune function and central nervous tissue demyelization was found when chicks were fed fish containing 0.4 ug/g (wet weight) or more MeHg (Kenow et al., 2007a; 2007b). Mercury-associated effects related to oxidative stress and altered glutathione metabolism occurred at 1.2 µg Hg/g and 0.4 µg Hg/g, an ecologically-relevant dietary mercury level, but not at 0.08 µg Hg/g (Kenow et al. in press).

Common Loon MeHg egg injection studies currently underway in Wisconsin are designed to establish the level of MeHg in loon eggs associated with reduced hatching rates, as well as the blood Hg concentrations of females producing eggs with comparable concentrations. These experiments have demonstrated that hatchability is reduced >40% when egg MeHg exceeds 1.3 ug/g wet weight, a level of MeHg found in Wisconsin loon eggs (Kenow et al. ms. in prep).

Studies comparing Canadian versus Wisconsin loon populations have identified mercury as an important stressor that is currently limiting loon production in Wisconsin (Burgess and Meyer 2008). Environment Canada and Wisconsin DNR scientists measured lake pH, mercury (Hg) concentrations in small fish, blood Hg levels in adult male, female and juvenile common loons, and loon productivity from 120 lakes in Wisconsin, USA and New Brunswick and Nova Scotia, Canada (Maritimes). Blood Hg concentrations in adult and juvenile loons decreased with lake pH and increased with Hg levels in fish prey. Loon Hg exposure, measured either as Hg levels in female loon blood or in fish prey, appeared to impose an upper limit on loon productivity. Loon productivity decreased as Hg exposure increased. Quantile regression analysis indicated that maximum observed loon productivity dropped 50% when fish Hg levels were 0.21 ug/g (wet wt), and failed completely when fish Hg concentrations were 0.41 ug/g. Loon prey MeHg concentrations frequently exceed 0.21 ug/g (wet wt.) on acidic lakes in Wisconsin.

A loon mercury population level risk assessment is currently underway in Wisconsin and New England, funded by USEPA STAR Cooperative Agreement R82-9085. We used recent developments in theoretical population ecology to construct basic models of loon demography and population dynamics. Parameterization of these models is made possible by bird banding studies and the long-running commitments monitoring of loon productivity. Our models include deterministic, two-stage, density independent matrix models yielding population growth rate estimates of 0.99 and 1.01 for intensively studied populations in Wisconsin and New Hampshire (Grear et al. in review). Preliminary model simulations indicate that reductions of Hg in fish in acidic lakes in Wisconsin can result in an improvement in the annual growth rate of the loon population in Wisconsin of approximately 1% (Meyer 2006).

It is essential that mercury emissions and mercury deposition from Wisconsin sources be reduced to the maximum extent feasible, to reduce the stressor of methylmercury, which can impair the reproduction of fish-eating wildlife, such as the Common Loon.

Comment

We Energies provided comments critical of the preliminary public health and welfare finding that a mercury emission standard for coal-fired power plants in Wisconsin is necessary.

We Energies references mercury modeling studies in their comments that they believe demonstrate that mercury emissions from coal-fired power plants are insignificant contributors to mercury contamination in Wisconsin. Their objection is expressed in the preface to their comments:

Overall we disagree with the finding that "a revised mercury emission standard for coal-fired [electric generating units] EGUs is necessary to protect public health and welfare from mercury exposure". This conclusion is not supported by any of the referenced studies. DNR's Finding fails to address, let alone answer, the crucial question: Are Wisconsin coal-fired power plants the sources of mercury to which Wisconsin residents are exposed?

In their comments on the preliminary finding, We Energies challenged this statement:

The State of Michigan estimates that emissions from coal-fired power plants comprise 50% Hg0, 30% RGM and 20% HgP, which implies that about half of the emitted mercury is readily deposited (Sills et al., 2007). However, a recent study shows that Hg0 undergoes atmospheric reactions that convert it to RGM and/or HgP enhancing the tendency for local and regional deposition (Lindberg et al., 2007).

WE Energies cited the June 2007 modeling study prepared by Atmospheric & Environmental Research, Inc. (AER) using the Trace Element Analysis Model (TEAM) that found less than 5% of mercury deposited in Wisconsin was caused by emissions from Wisconsin coal-fired power plants. They also noted the opinion of Dr. O. Russell Bullock, Meteorologist with the Atmospheric Model Development Branch of the National Oceanic and Atmospheric Administration, who provided his opinion at the Natural Resources Board Mercury Seminar in July 2007 that less than 10% of mercury deposition in the contiguous U.S. is from domestic coal-fired utility boilers. Dr. Bullock uses EPA's CMAQ (Community Multiscale Air Quality) model in support of his mercury deposition estimation

Response Summary

THERE IS SUFFICIENT EVIDENCE TO CONCLUDE THAT A CONTROL STANDARD FOR MERCURY REDUCES MERCURY DEPOSITION FROM COAL-FIRED ELECTRIC GENERATING UNITS IN THE STATE

Response Analysis

Mercury exists in the atmosphere in three basic forms, reactive gaseous mercury (RGM), elemental mercury (Hg0) and particle-bound mercury (HgP). All three species are subject to:

1. Atmospheric reactions with other pollutants such as ozone,

2. Dry deposition as the mercury species come in contact with surfaces,

3. Wet deposition as mercury is incorporated into rain, fog or snow.

In the preliminary public health and welfare finding, the contribution of mercury deposition in Wisconsin by mercury emissions from our coal-fired power plants was determined to be significant enough to warrant regulation. That determination was based in part on the following:

The State of Michigan estimates that emissions from coal-fired power plants comprise 50% Hg0, 30% RGM and 20% HgP, which implies that about half of the emitted mercury is readily deposited (Sills et al., 2007). However, a recent study shows that Hg0 undergoes atmospheric reactions that convert it to RGM and/or HgP enhancing the tendency for local and regional deposition (Lindberg et al., 2007).

Some models used to simulate mercury transport and transformation are called chemical transport models including AER's TEAM model and Total Risk of Utility Emissions (TRUE) model and Environ's Comprehensive Air quality Model with extensions (CAMx), and EPA's CMAQ model. These chemical transport models employ different mathematical techniques to simulate the transport of mercury, the chemical transformations of mercury and other chemical species, the physics of deposition, and meteorological parameters such as rainfall. Much uncertainty exists in these key modeling parameters that govern most of the chemical and physical properties of the mercury species simulated in chemical transport models. Since atmospheric mercury modeling is relatively new and extremely complex, there is a significant degree of uncertainty in model findings. Furthermore, it is very difficult to measure mercury species and trace mercury reactions at typical atmospheric concentrations, so there is little or no real world verification of many critical atmospheric processes that influence mercury deposition. Modeling studies are important but should not be relied upon to be the only data considered when evaluating mercury deposition from local sources.

Observation based models are a powerful check on the chemical transport models. Observation based models employ actual measurements to establish a relationship between emissions and pollutant concentrations. This helps to overcome the inherent weakness in mercury emission estimates used in chemical transport models. Rutter, *et. al.* applied an observation based model to evaluate the impact on mercury concentrations in Wisconsin from local point sources.

The following is a summary of additional analyses that leads to the conclusion that a control standard for mercury reduces mercury deposition from coal-fired electric generating units in the state:

- Historic chemical transport modeling studies have underestimated the contribution from local sources due to an underestimation of dry deposition rates and other modeling problems.

- The atmospheric mercury cycle is more dynamic than previously thought, with short residence times perhaps on the order of hours to days. Therefore, emitted mercury may not travel far from a source before being deposited onto forest vegetation, soils or surface waters (Gustin *et. al.*, 2008).

- Evaluation of ambient mercury measurements cast significant doubt on the hypothesis that an overwhelming amount of the mercury deposition in Wisconsin can be attributed to global or regional sources.

- Recent research (Rutter, *et. al*., 2008), using ambient mercury measurements, demonstrated that local mercury point sources contributed 63% to the reactive gaseous mercury concentration in Milwaukee and 48% at Devil's Lake State Park, Sauk County.

- Recent research, such as Manolopoulos, *et. al.,* 2008, demonstrates there is a significant local point source contribution to reactive gaseous mercury concentrations in Wisconsin.

- Eight to 10% is the lower bound for what could be expected for contribution to mercury deposition in Wisconsin from the state's coal-fired power plants.

More detail is provided below.

1. Historic mercury deposition modeling studies underestimate the impact of local sources.

The AER models, TEAM and TRUE, and other models using the same deposition algorithms and model configurations, have two major weaknesses that systematically underestimate the contribution of local sources to mercury deposition.

The first weakness concerns dry deposition velocity. In the AER models, the dry deposition velocities for both divalent and elemental mercury are substantially less than estimates used in EPA's CMAQ model. In the AER models, a single estimate of 0.5 cm/s (centimeters per second) for the dry deposition velocity for divalent mercury, is a factor of 3 to 5 less than the estimates in CMAQ for Wisconsin. Similarly, the AER models single estimate of 0.01 cm/s for the dry deposition velocity of elemental mercury is also a factor of 3 to 5 less than the estimates in CMAQ for Wisconsin. The net result of the underestimation of dry deposition velocity is an underestimate of local source contribution to mercury deposition and an overestimation of mercury deposition due to distant sources.

The second weakness concerns the assumption for the top boundary of the atmosphere in the model. The AER models cap the top of the modeling domain at 7 Km (kilometers). The Department's mercury modeling study (*Development of an Atmospheric Mercury Modeling System for the Great Lakes Region*) and the report from Environ (*Modeling Atmospheric Mercury Chemistry and Deposition with CAMx for a 2002 Annual Simulation*) indicate that the top boundary assumption is critical and can be an overwhelming factor in determining wet deposition estimates. Environ recommended that the top boundary be set at the bottom of the stratosphere, much higher than 7 Km. When the Department implemented this change in their modeling study, it significantly improved model performance. The net result of using the 7 Km height for the top boundary condition is likely an overestimate of the percentage contribution from distant sources and an underestimate of the percentage contribution from local sources.

In addition to the these inherent model weaknesses, the Department's analysis of event sampling data at Devils Lake State Park indicates that a significant portion of annual mercury deposition may fall during relatively short term events, such as summertime thunderstorms. To date, most mercury modeling studies like the AER models use a large grid structure that does not properly consider mercury deposition during thunderstorms. Intense precipitation events are effective at scavenging divalent mercury, leaving little atmospheric mercury for long range transport. The net result of sacrificing grid structure for computational efficiency

may be an underestimation of the local source contribution to wet mercury deposition and an overestimation of the contribution to wet mercury deposition from distant sources

2. Fate of Mercury in the Environment

Early studies of atmospheric mercury suggested that it remained in the atmosphere for about one year, the estimated time needed to attain a relatively uniform air concentration (~2ng Hg/m3) across the northern hemisphere (Lindqvist, 1985; Fitzgerald, 1989). Such long residence times implied that emitted mercury was transported far away from sources. However, more recent studies indicate that the atmospheric mercury cycle is more dynamic than previously thought, with short residence times perhaps on the order of hours to days (Gustin et al., 2008). These studies imply that emitted mercury may not travel far from a source before being deposited onto forest vegetation, soils or surface waters. Such rapid removal of mercury from air is not simply a function of chemical speciation in stack gases, but it also depends upon reactions that occur in the atmosphere during transport as well as reactions that occur on impacted surfaces.

Re-emission of newly deposited mercury on daily time scales can result in a "multi-hop" phenomenon, so that the behavior of atmospheric mercury has been compared to a ping-pong ball bouncing on a stone floor with patches of soft carpet (Hegdecock and Pirrone, 2004; Jervelov, 2000). Rapid exchanges of mercury between air and earth surfaces may give the appearance of homogeneous air concentrations, explaining the over-estimation of residence times in early studies (Gustin et al., 2008). In studies of our sensitive Wisconsin lakes, data indicate that most of the mercury which enters the lakes stays in the lakes – behaving, metaphorically, as "soft carpet patches" (Watras et al., 1994).

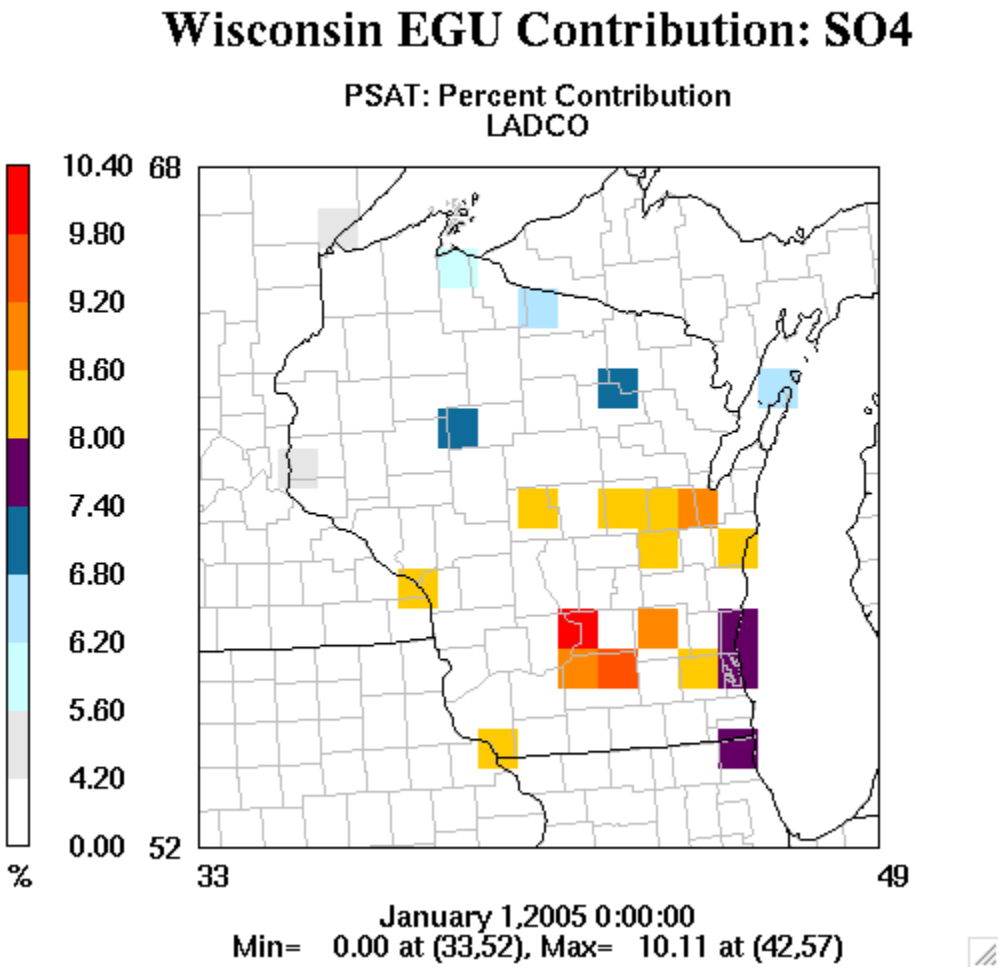
3. Sulfate as a Mercury Tracer

Due to the significant uncertainties surrounding the accuracy of atmospheric mercury modeling, the Department, in conjunction with the Lake Michigan Air Directors Consortium (LADCO), used another approach to assess mercury deposition from Wisconsin sources. The technique involves approximating the contribution of Wisconsin power plants to mercury deposition using sulfate as a tracer for mercury. The technique works, because 1) power plants are the principal source of mercury and sulfate ion in Wisconsin, 2) the CAMx model performs very well at simulating sulfate concentrations, and 3) the PSAT algorithm in CAMx allows one to trace sulfate back to its source.

The modeling results, presented in Figure 1 below, show that Wisconsin power plants are responsible for approximately 6 to 10% of the annual sulfate ion concentration at fine particle monitoring sites in the state.

Although sulfate is subject to deposition, ammonium sulfate particles are not as readily deposited as is mercury in the reactive gaseous form. Therefore, a 6 to 10% estimate of mercury deposition from Wisconsin's coal-fired power plants would be a lower bound of the expected mercury deposition. In any event, wet deposition of mercury from Wisconsin's coal-fired power plants is likely to be much larger than the 1 or 2 % contribution postulated in stakeholder comments on the proposed mercury rule.

Figure 1



4. Local Deposition Assessment from the National Mercury Deposition Network

A comparison of Mercury Deposition Network (MDN) data indicates marked differences in annual average mercury concentration and mercury deposition rates in different geographic regions of the U.S. Areas in the rural locations in the northeastern U.S. have long-term average mercury deposition rates that are about half of those in many rural Wisconsin locations, but on average, the northeastern U.S. locations receive from 5 to 20 more inches of precipitation in a year. A possible explanation is that coal used for electric power generation in Wisconsin and the Midwest contributes to higher deposition rates in Wisconsin and the lower deposition rates in the Northeast result from the predominate use of oil for electric power generation in that area of the U.S.

In addition, national MDN data indicates significant regional and site-specific differences in mercury deposition trends in the eastern half of the U.S. These regional differences occur despite the fact that MDN sites are typically in rural areas in an attempt to limit the effects of local sources on the monitors. It is very likely that the differences in deposition are a result of strong influence of local and regional emission sources on measured wet deposition (TJ Butler *et. al*., 2008).

Electric utility representatives have postulated that mercury deposition in the U.S. is dominated by the contribution from global sources and that mercury emissions from sources outside North America are increasing. However, the fact that mercury deposition in the eastern U.S. was found to be gradually declining in a recent research paper (TJ Butler *et. al*., 2008) contradicts a hypothesis that global mercury dominates deposition in the U.S.

5. Recent Research - Ambient Measurements of Mercury in Wisconsin

Recently published research (Rutter et al., 2008) indicates that point sources in Wisconsin and neighboring states significantly impact measured concentrations of mercury species at two measurement locations in Wisconsin. Researchers at the University of Wisconsin - Madison performed measurements of gaseous elemental mercury (Hg0), particulate mercury (HgP), and divalent mercury, also know as reactive gas mercury (RGM). The scientists identified regional and local mercury source regions and calculated an estimate of source impacts on atmospheric concentrations of elemental and reactive species at Devil's Lake State Park and Milwaukee.

Point sources were determined to impact concentrations at the monitoring sites by virtue of short, episodic increases in mercury species that were too large and irregular to be explained by photochemistry or contributions from natural sources. When mercury concentrations exceeded 3 times the standard deviation of the reference mean, the values were interpreted as discrete periods when anthropogenic point sources were directly impacting the monitoring site.

Pollution roses of elevated mercury concentrations were constructed for each location (Supplement). Frequent, elevated mercury concentrations were caused by point sources in Milwaukee and Kenosha counties in Wisconsin, as well as some counties in Illinois, Indiana and Michigan. Devil's Lake State Park was impacted by point sources located in the counties to the southeast (Columbia, WI; Milwaukee, WI; Cook; IL, Du Page IL; Will, IL), southwest (Grant, WI; Linn, IA) and west (Vernon, WI; Allamakee, IA.).

The research demonstrates that point sources within tens of kilometers downwind of both monitoring sites strongly influence mercury measurements. Importantly, the research team determined the point source contribution to reactive mercury (RM), the sum of HgP and RGM, is 48% at Devil's Lake State Park and 64% at Milwaukee (Table 1).

Table 1 - Contributions of Point and Area Sources to Annual Average HG0 and RM Concentrations at Devil's Lake State Park and Milwaukee, Wisconsin

	Devil's Lake State Park					Milwaukee				
	Annual Average Conc.	Area[a] Source	%	Point Sources	%	Annual Average Conc.	Area[a] Sources	%	Point Sources	%
Hg0 (ng/m^3)	1.62	1.58	98	0.04	2	2.48	1.67	67	0.81	33
RM (pg/m^3)	11.8	6.0	52	5.7	48	21.7	7.9	36	13.8	64

(a) Area sources are the sum of all of the other mercury sources contributing to the monitored concentration, other than the mercury concentration attributed to the discrete point sources.

In a related study, (Manolopoulos, 2008 *et. al.*), researchers made ambient mercury measurements concurrently at two rural locations in southern Wisconsin. The researchers measured atmospheric elemental mercury, divalent mercury, and particulate mercury (HgP) concentrations from April through September 2003 at Mt. Horeb in Dane County and Devil's Lake State Park which are located approximately 40 miles apart. Sulfur dioxide was also monitored at Devil's Lake State Park.

The researchers observed frequent, significant peaks in divalent mercury concentration at Devil's Lake State Park that coincided with peaks in SO_2 concentrations. These measurements are indicative of point source plume impacts. Similar contemporaneous peaks were not noted at Mt. Horeb. The authors concluded that the marked difference in divalent mercury concentrations indicate that the source(s) of divalent mercury to each site was local.

The researchers identified five events where divalent mercury spikes (concentrations exceeding 75 pg/m^3 at Devil's Lake State Park) were coincidental with significant increases in SO_2. The similar behavior between SO_2 and divalent mercury suggests that the same source emitted both species. Gaussian plume dispersion modeling and meteorological data identified the SO_2 emission source to be a coal-fired power plant in Columbia County.

Section 3 - What are the Options to Control Risks from Mercury Emission Exposures?

Preliminary Finding Summary
Developing a revised emission standard for coal-fired electric generating units to protect public health under the provisions of s. 285.27(2)(b) Wis. Stats. is the most appropriate option to achieve significant mercury emission reductions from stationary sources since coal-fired electric generating units are the stationary source category that accounts for the majority of mercury emissions in Wisconsin.

The costs of mercury control technologies applicable to coal-fired electric generating units found in Wisconsin are reasonable and cost-effective in comparison to the costs to control conventional pollutants from this stationary source category, including particulate matter, nitrogen oxides and sulfur dioxide. Multipollutant approaches are preferred because environmental and public health benefits can be achieved at lower costs.

The costs of mercury control technology applicable to coal-fired electric generating units in Wisconsin are reasonable and cost-effective. Technologies are commercially available and are capable of achieving 90% reduction. For example, the cost of sorbent injection with existing particulate control equipment is expected to range from 0.04 to 0.15 cents per kilowatt hour for all electric generating unit sizes and a Toxecon® system costs in the range of 0.12 to 0.24 cents per kilowatt hour for large electric generating units with both approaches achieving 90% mercury removal. Similar control efficiencies can be achieved at lower cost when mercury control is integrated into a multipollutant control system. The mercury portion of multipollutant control costs could be as low as 0.04 to 0.1 cents per kilowatt hour, while achieving mercury removal efficiencies in the range of 80% to 95%.

Comment
Wisconsin electric utilities are concerned that mercury control technologies appropriate for their coal-fired electric generating units are not commercially available and that mercury control technologies under development may not be able to achieve a high level of reductions.

The rule's 90% emission reduction requirement will be a technology challenge, and the costs associated with this high level of emissions reduction are not known with certainty at this time - We Energies.

WPL will try to achieve 90% mercury reduction, but believes it is only realistic to propose such limits when there is long-term actual operational experience to support this level of stringency - Wisconsin Power & Light Company.

Response Summary
EFFECTIVE MERCURY CONTROL TECHNOLOGY WILL BE AVAILABLE TO MEET THE PROPOSED RULE REVISIONS

Response Analysis
The March 2008 Preliminary Public Health and Welfare Finding identified the nature of Wisconsin's utility electric generating sector, the challenges to achieving mercury emission reductions from coal-fired electric generating units and the approaches that can lead to significant mercury emission reductions at reasonable costs. The mercury control

requirements being proposed in Chapter NR 446, Control of Mercury Emissions, Wis. Adm. Code, reflect the evaluation in the preliminary finding.

In Wisconsin, electrical energy is primarily provided by coal combustion and the principal coal types used are subbituminous and bituminous. Subbituminous coal firing accounts for 84% of our coal-fired electric generating capacity. As outlined in the preliminary finding, a critical issue for many of the electric utilities is the affect of activated carbon on the reuse of fly ash as a concrete additive. The type of coal combusted also has an effect on the suitability of fly ash for reuse. Fly ash from bituminous coal-fired electric generating units typically does not have the right chemical characteristics for use as a cement additive.

Activated carbon is a commercially available mercury control technology and capable of achieving removal efficiencies of 90% or greater. However, activated carbon, makes the fly ash unusable as a concrete additive. As a result, fly ash contaminated with activated carbon would require placement in a landfill if another recycling option was not available. Activated carbon is still an important mercury control approach that can be applied in situations where fly ash recycling is not a consideration. A specially formulated activated carbon sorbent, C-PAC® is available that is concrete friendly and capable of 90% mercury reductions. Regardless, in all cases a Toxecon® system can be used to avoid fly ash reuse impacts. However, this approach is typically reserved for large coal-fired electric generating units.

For the large coal-fired electric generating units in the state, mercury control technologies that do not contaminate fly ash and can be integrated with multipollutant control systems are currently planned or being considered for installation. These mercury control technologies have been demonstrated to be effective or are on a development path that will allow them to be commercially available within the compliance schedule and capable of meeting the mercury emission limitations being proposed under the multipollutant option.

Comment

Wisconsin electric utilities are concerned that the costs for suitable mercury control technologies cannot be estimated at this time and may be substantial.

Response Summary

MERCURY CONTROL TECHNOLOGY COSTS ARE REASONABLE IN COMPARISON TO CRITERIA POLLUTANT CONTROL TECHNOLOGY COSTS PARTICULARLY IF A MULTIPOLLUTANT CONTROL APPROACH IS PURSUED

Response Analysis

The cost of mercury control technology applicable to coal-fired electric generating units in Wisconsin are reasonable and cost-effective. These technologies, including sorbent injection with a Toxecon® system or with existing particulate control equipment, are commercially available and are capable of achieving 90% reduction. Similar control efficiencies can be achieved at lower cost when mercury control is integrated into a multipollutant control systems. Multipollutant approaches are preferred because additional environmental and public health benefits can be achieved at lower costs. It is a opportune time to consider a multipollutant approach to reducing mercury since most of the electric utilities in Wisconsin are currently in the process of planning and installing equipment to control other pollutants.

Section 4 - What are Neighboring States Doing to Address Mercury Emissions from Coal-fired Electric Generating Units?

Preliminary Finding Summary
Among neighboring states, Illinois, Michigan and Minnesota are proposing or have adopted requirements more stringent than Wisconsin's current rule. Under the proposed rule, Wisconsin, like Illinois, Michigan and Minnesota, is requiring large electric generating units to achieve a 90% reduction based on mercury in coal combusted. Dates by which compliance with this mercury emission standard is required varies from 2009 to 2021. In part, this variation can be attributed to the availability of multipollutant reduction options that extend the mercury reduction compliance date in exchange for reductions in sulfur dioxide and nitrogen oxides. Wisconsin, like Illinois and Michigan, will include mercury emission standards for new coal-fired electric generating units.

Finding
THE PROPOSED RULE REVISIONS CONSIDERS THE SITUATION IN WISCONSIN AND ARE COMPARABLE TO REQUIREMENTS IN OUR NEIGHBORING STATES

Comment
Wisconsin electric utilities have emphasized that the approaches taken to achieve mercury emission reductions in neighboring states were developed to take into account their unique situations and include provisions in their requirements that reflect those situations. Environmental organizations are concerned that the mercury reduction levels and schedules they prefer and that are being implemented in our neighboring states are not reflected in the mercury control standard being proposed.

Analysis and Response
Wisconsin, like Illinois, Michigan and Minnesota, is proposing to require coal-fired electric generating units to achieve a 90% reduction based on mercury in coal combusted. Compliance deadlines with this 90 % mercury emission standard in these state requirements varies from 2009 to 2021. In part this variation can be attributed to the availability of multipollutant reduction options that extend the mercury reduction compliance date in exchange for reductions in sulfur dioxide and nitrogen oxide. Each of these four states has built-in to their requirements compliance flexibility such as emission averaging and less restrictive requirements for smaller electric generating units.

Illinois, Michigan, and Wisconsin have included specific mercury emission standards for new coal-fired EGUs or power plants.

Illinois, Michigan and Minnesota all have law or regulations that require a 90% reduction based on mercury in coal combusted. Michigan requires compliance by January 1, 2015. Illinois requires compliance with their mercury emission standard by July 1, 2009 and Minnesota established a compliance date of December 31, 2010 or December 31, 2014 depending upon the type of sulfur dioxide or nitrogen oxide emission control system being used.

In Indiana and Ohio there are no specific mercury reduction requirements for coal-fired electric generating units. These states developed regulations to meet the now vacated federal CAMR through participation in EPA's national trading program.

Averaging can be used to demonstrate compliance with the 90% mercury emission standard in Illinois until December 31, 2013 provided that each unit achieves a 75% reduction of mercury in coal combusted. An individual unit or multiple units may demonstrate compliance with the Illinois mercury emission standard by demonstrating that actual emissions are less than allowable emissions over a rolling 12-month period.

In Michigan, compliance can be demonstrated unit-by-unit, power plant-wide or system-wide at the choice of an owner or operator. The compliance approach can also change from year-to-year at the owner or operators discretion with advance notification. Small coal-fired EGUs, with mercury emissions less than 9 pounds per year, can propose an alternative reduction plan. Technical or economic exceptions to the mercury emission standard may also be provided.

Minnesota allows up to a 12-month extension to their compliance dates and units that are equipped with wet scrubbers to reduce sulfur dioxide emissions can substitute a different unit for a targeted unit in their mercury control law.

Under the Wisconsin rule proposal, coal-fired EGUs under common ownership or control may average to achieve the proposed mercury emission standard or multipollutant requirements for sulfur dioxide and nitrogen oxide.

References

Section 1

RISK TO NATIVE AMERICAN POPULATIONS

Methodology for Deriving Water Quality Criteria for the Protection of Public Health, United States Environmental Protection Agency, Office of Water & Office of Science and Technology, EPA 822-B-00-004, October 2000.

WDNR Special Advice for Mercury 2007

ESTIMATING THE NUMBER OF WISCONSIN RESIDENTS POTENTIALLY AFFECTED

Salonen, et al. Intake of Mercury from Fish, Lipid Peroxidation, and the Risk of Myocardial Infarction and Coronary Cardiovascular, and Any Death in Eastern Finnish Men. Circulation. 1995; 91:645-655.

Grandjean P, Murata K, Budtz-Jorgensen E, Weihe P. 2004. Cardiac autonomic activity in methylmercury neurotoxicity: 14-year follow-up of a Faroese birth cohort. J Pediatr. 144:169-76.

Section 2

HEALTH BENCHMARK

Salonen, et al. Intake of Mercury from Fish, Lipid Peroxidation, and the Risk of Myocardial Infarction and Coronary Cardiovascular, and Any Death in Eastern Finnish Men. Circulation. 1995; 91:645-655.

Grandjean P, Murata K, Budtz-Jorgensen E, Weihe P. 2004. Cardiac autonomic activity in methylmercury neurotoxicity: 14-year follow-up of a Faroese birth cohort. J Pediatr. 144:169-76.

REDUCTIONS IN MERCURY COMPARED TO SULFATE REDUCTIONS

Harris, R., Rudd, J.W.M., Amyot, M. and others. 2007. Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition. Proceedings of the National Academy of Sciences **104**(42): 16586-16591.

Hrabik T. R. and Watras, C.J. 2002. Recent declines in mercury concentrations in a freshwater fishery: isolating the effects of de-acidification and decreased atmospheric mercury deposition in Little Rock Lake. Sci. Total Environ 297:229-237.

Orihel, D.M., Paterson, M.J., Gilmour, C.C., Bodaly, R.A., Blanchfield, P.J., Hintelmann, H., Harris, R. and Rudd, J.W.M. 2006. Effect of loading rate on the fate of mercury in littoral mesocosms. Environmental Science and Technology **40**(19): 5992-6000.

Paterson, M.J., Blanchfield, P.J., Podemski, C., Hintelmann, H., Gilmour, C.C., Harris, R., Ogrinc, N., Rudd, J.W.M. and Sandiland, K.A. 2006. Bioaccumulation of newly deposited mercury by fish and invertebrates: an enclosure study using mercury isotopes. Can. J. Fish. Aquat. Sci. **63**: 2213-2224.

Urban, N.R. and Monte, A.E. 2001. Sulfur burial and loss from the sediments of Little Rock Lake, Wisconsin. Can. J. Fish. Aquat. Sci. **58**: 1347-1355.

Watras, C.J., Morrison, K.A., Hudson, R.J.M., Frost, T.M. and Kratz, T.K. 2000. Decreasing mercury in northern Wisconsin: Temporal patterns in bulk precipitation and a precipitation-dominated lake. Environ. Sci. Tech. 34(19): 4051-4057.

Watras, C.J., Morrison, K.A. and Kratz, T.K. 2002. Seasonal enrichment and depletion of Hg and SO_4 in Little Rock Lake: relationship to seasonal changes in atmospheric deposition. Can. J. Fish. Aquat. Sci. **59**: 1660-1667.

COMMON LOON REPRODUCTIVE SUCCESS

Burgess, N.M. and Meyer, MW. 2008. Methylmercury exposure associated with reduced productivity in common loons. Ecotoxicology 17(2): 83-91.

Grear, JW, Meyer, MW, Cooley, JH, Kuhn, A, Piper, WH, Mitro, MG, Vogel, HS. (In review) Population growth and demography of a long-lived piscivorous bird in lakes of the northern United States. Journal of Wildlife Management.

Kenow, K.P., Gutreuter, S., Hines, R.K., Meyer, M.W., Fournier, F., Karasov, W.H. (2003). Effects of methyl mercury exposure on the growth of juvenile common loons. Ecotoxicology 12 171-182.

Kenow, KP, Grasman, KA, Hines, RK, Meyer, MW, Gendron-Fitzpatrick, A, Spalding, M, Gray, BR. 2007. Effects of methylmercury exposure on the immune function of juvenile common loons. Environmental Toxicology and Chemistry 26: 1460-1469.

Kenow, KP, Meyer, MW, Hines, RK, Karasov, WH. 2007. Distribution and accumulation of mercury in tissues and organs of captive-reared common loon (*Gavia immer*) chicks. Environmental Toxicology and Chemistry 26(5)1047–1055.

Kenow, KP, Hoffman, DJ, Hines, RK, Meyer, MW, Bickham, JW, Matson, KW, Stebbins, KR, Montagu, P, and Elfessi, A. (In Press). Effects of methylmercury exposure on glutathione metabolism, oxidative stress, and chromosomal damage in captive-reared common loon (*Gavia immer*) chicks.

Meyer, MW. 2006. Evaluating the Impact of Multiple Stressors on Common Loon Population Demographics - An Integrated Laboratory and Field Approach. USEPA STAR Grant R82-9085, Final Report. July 31, 2006.

Meyer, M.W., D.C. Evers, J.J. Hartigan, P.W. Rasmussen. 1998. Patterns of common loon (Gavia immer) mercury exposure, reproduction, and survival in Wisconsin. Env. Toxicol. Chem. 17(2) 184-190.

Meyer, M.W., D. Evers, and T. Daulton. 1995. Common loons nesting on acidified lakes in northern Wisconsin have elevated mercury exposure. Water, Air, and Soil Pollution 80: 871-880

Scheuhammer, AM, Basu, N, Burgess, NM, Elliott, JE, Campbell, GD, Wayland, M, Champoux, L, Rodrigue, J. 2008. Relationships among mercury, selenium, and neurochemical parameters in common loons (*Gavia immer*) and bald eagles (*Haliaeetus leucocephalus*). Ecotoxicology (2008) 17:93–101.

MODEL UNDERESTIMATION OF LOCAL MERCURY SOURCE IMPACT

Wisconsin DNR, Development of an Atmospheric Mercury Modeling System for the Great Lakes Region, Final Report to the United States Environmental Protection Agency, Grant No. X97579601, June 23, 2004.

Greg Yarwood, Steven Lau, Yiqin Jia, and Prakash Karamchandani, November 2003, Final Report, Modeling Atmospheric Mercury Chemistry and Deposition with CAMx for a 2002 Annual Simulation**,** Prepared for Wisconsin Department of Natural Resources, ENVIRON International Corporation.

FATE OF MERCURY IN THE ENVIRONMENT

Fitzgerald, W.F. 1989. Atmospheric and Oceanic Cycling of Mercury. *In* Chemical Oceanography Series. *Edited by* J.P. Riley and R. Chester. Academic Press. pp. 151-186.

Gustin, M.S., Lindberg, S.E., and Weisberg, P.J. 2008. An update on the natural sources and sinks of atmospheric mercury. Applied Geochemistry 23: 482-493.

Hedgecock, I.M., Pirrone, N. 2004. Chasing quicksilver: modeling the atmospheric lifetime of $Hg^{0}_{(g)}$ in the marine boundary layer at various latitudes. Environ. Sci. Technol. 38: 69-76.

Jernelov, A. 2000. Some comments on biological methylation, global emissions and trade and on residence time in atmosphere of mercury. Journal of Environmental Sciences 12(Supplement): 102-107.

Watras, C. J.; Bloom, N. S.; Hudson, R. J. M.; Gherini, S.; Munson, R.; Claas, S. A.; Morrison, K. A.; Hurley, J.; Wiener, J. G.; Fitzgerald, W. F.; Mason, R.; Vandal, G.; Powell, D.; Rada, R.; Rislov, L.; Winfrey, M.; Elder, J.; Krabbenhoft, D.; Andren, A. W.; Babiarz, C.; Porcella, D. B.; Huckabee, J. W. 1994. Sources and fates of mercury and methylmercury in Wisconsin lakes. In Mercury Pollution: Integration and Synthesis; Watras, C. J., Huckabee, J. W., Eds.; Lewis Publishers. pp 153-177.

LOCAL DEPOSITION ASSESSMENT FROM THE NATIONAL MERCURY DEPOSITION NETWORK

TJ Butler, MD Cohen, FM Vermeylen, GE Likens, D Schmeltz, RS Artz, 2008; “Regional precipitation mercury trends in the eastern USA, 1998–2005: Declines in the Northeast and Midwest, no trend in the Southeast,” *Atmosph. Env. 42*, 1582–92.

Written Testimony provided to the Committee on Environment and Public Works, United States Senate, Washington, D.C., Leonard Levin, Ph.D., Technical Executive, Electric Power Research Institute, Palo Alto, California, May 13, 2008.

RECENT RESEARCH - AMBIENT MEASUREMENTS OF MERCURY IN WISCONSIN

A.P. Rutter, J.J. Schauer, G.C. Lough, D.C. Snyder, C.J. Kolb, S. Von Klooster, T. Rudolf, H. Manolopoulos and M.L. Olson, *J. Environ. Monit.*, 2008, 10, 102-108.

Supplementary Material (ESI) for Journal of Environmental Monitoring. The Royal Society of Chemistry 2007.

H. Manolopoulos, J.J. Schauer, M.D. Purcell, T.M. Rudolph, M.L. Olson, B. Rodger and D. Krabbenhoft, *Journal of Environmental Engineering and Science*. 2007, Vol. 6, 5, 491-501.